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Special Projects Office (IMBA-1)
Plans & Programs Office
Directorate of Production
Wright-Patterson AFB, Ohio

SUBJECT: Monthly Progress Report
Contract AF 33(600)-40280

Enclosure (1): Three (3) copies Monthly Progress Report for Period
2/15/62 to 3/15/62.

Gentlemen:

Enclosure (1) is submitted as required by the subject contract.
One copy of this report is also being sent to [redacted]

25X1

Very truly yours,

WESTINGHOUSE ELECTRIC CORPORATION

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Marketing Department

RWE:sf

cc: [redacted]

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Progress Report

Period of 2/15/62 to 3/15/62

Contract No. AF33(600)40280

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Flight Test Program

A. General I

During this reporting period two (2) system flights were made. The first produced no data due to failure of the recorder. The second flight was valuable in that actual targets were recorded and processed. This success shows that the radar and processing is functioning as a system. Although the quality was not as good as desired the results allowed an analysis of problem areas and solutions to these problems are underway.

General II

Of the 19 working days in this period, the F-101B aircraft was on "up" status for 10 days, on system modification status for 2 days and down for maintenance during 7 days. Two flights with the system in operation were made during this period. Among the aircraft maintenance problems encountered during the period were:

1. A leak developed in the stabilator hydraulic actuator, requiring replacement of the unit.
2. One hydraulic shuttle valve was replaced due to leakage.
3. The left hand main landing gear side brace actuator was replaced in compliance with a grounding directive from the Air Force.
4. The aft cabin refrigeration unit turbine failed in flight and was replaced.

B. APQ-93 System

The following is a summary of APQ-93 system work performed during the reporting period.

February 15 - Following the pod flutter flight of February 13, the power out of the KPA was found to be low.

February 19 - A new KPA was installed. During the next two week period, modifications and repairs were completed to correct malfunctions in the following areas.

1. Noise failure circuit.
2. CRT failure circuit.
3. Light leak in the APQ-93 recorder.
4. KPA overheating - a new blower was added which apparently solved the overheat problem. No overheating occurred during the rest of the reporting period.

The APN-102 antenna was aligned to the APQ-93 antenna so that drift angle signals would be referenced to the APQ-93 antenna.

March 2 - The system performed well during preflight checkout.

March 3 - The first system flight (Sh) with an antenna was made.

No system film data was obtained because of a failure in the recorder. The cause of this failure was a high voltage arc and subsequent fuse failure. Analysis of the instrumentation oscillograph recording of this flight is included in the Data Analysis section of this report.

- March 7 - Because of gradual deterioration of noise figure, the
TWT was changed and filtering incorporated into the S+
signals.
- March 8 - Modulator high voltage power supply failed.
- March 12 - System flight (S5) made. Film and oscillograph data
obtained. See Data Analysis.

During most of the reporting period, problems were encountered
in obtaining the rated power out of the transmitter.

C. Instrumentation

During this reporting period work has continued toward increasing
the capability and improving the performance of the instrumentation
configuration in the F-101B.

Three new signals have been added for recording.

1. AGC
2. 28 VDC Power Line Voltage
3. Accelerometer Summing Network Output

The following improvements were made to the present configuration.

1. A summing network has been included to perform a vector
addition of the outputs of the normal and vertical
accelerometers in the pod. The resultant acceleration
along the antenna beam center can be recorded directly.
2. Low pass RC filters, with a 3 db corner set at 10 cps,
(12 db/octave) have been incorporated into the accelerometer
outputs.

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3. The sensitivity of the "ground speed" and "distance off track" signals has been increased.
4. The 15 cps ripple which had distorted signals on several channels has been reduced.
5. Malfunctions have been corrected in the data correlation unit Ledex switch and in the data correlation pulse circuit.

D. Data Analysis

1. Summary

Results of flight S5 film recording.

Film recorded from this flight was checked prior to processing for presence of data and exposure (density). Targets were apparent on the film although not a large number were present. The film density appeared to be greater than expected but not by a significant amount.

The film was then processed after some difficulties in the processor were corrected.

Analysis of the processed film indicated the system sensitivity was low and that the range resolution was well below specifications. These results confirmed ground tests which indicated that range resolution would be degraded due to leakage from the wide modulator pulse into the resonant ring output. The sensitivity was low due to low power output and degradation of noise figure. Both of these items have been improved by recent corrective action. Measures taken to date have reduced the leakage by 10 db and the noise figure by 1 db from the condition present on this flight. These improvements are not considered to be the final but are sufficient until further flight results are obtained.

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Improvements to date were obtained by using air to sweep the arc out of the switches which improved the narrow pulse to leakage pulse ratio. Actual reduction in leakage pulse was accomplished by optimization of buffer pulsewidth. Changing ring tuning criterion from maximum power output to maximum sensitivity (compromise between insertion loss and maximum power).

Future improvement programs are directed to improving power out by optimizing the shorts and switches. Noise figure improvements are being considered but the method has not been decided upon as of this date.

One anomaly observed on the raw film that was partly explained was that the apparent doppler on the film was lower than expected. This would normally be caused by improper navigation information. The APN-102 and all associated equipment have been checked and no discrepancy has been found. The radar beam was found to be shifted 0.3" which would account for 120 cps of the shift. The offset was adjusted to correct the apparent doppler to the desired value.

2. Flight 94 (3/3/62) was flown over a pre-planned mountain course at Mach 1.5 at 40,000 feet.

No APQ-93 film data was obtained during the flight because of a fuse failure in the Cathode Ray Tube circuit of the system recorder. The failure occurred when the system was switched to the "film run" mode of operation. Arcing in the recorder high voltage power supply was probably the cause of the failure.

The instrumentation GNC Recorder operated throughout the data run. The following is a summary of the data obtained:

SYSTEM PARAMETERS:

- a. Power Supplies: All power supplies operated normally during the flight.

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- b. Temperatures: Four thermistors were instrumented during the flight. The results are tabulated below:

| <u>Location</u> | <u>Temp. at End. Run Before Take Off</u> | <u>Temp. at Start of Data Run</u> | <u>Temp. at End of Data Run</u> | <u>Temp. After Landing</u> |
|--|--|---|---|--------------------------------|
| Duplexer Surface | 73°F | 55°F | 59°F | 64°F |
| High Voltage Power Supply Air | 108°F | 115°F | 118°F | 119°F |
| Pulse Network Surface | 107°F | 108°F | 109°F | 113°F |
| Nose Air (Instrumentation Compartment) | 56°F | 41°F | 41°F | 40°F |

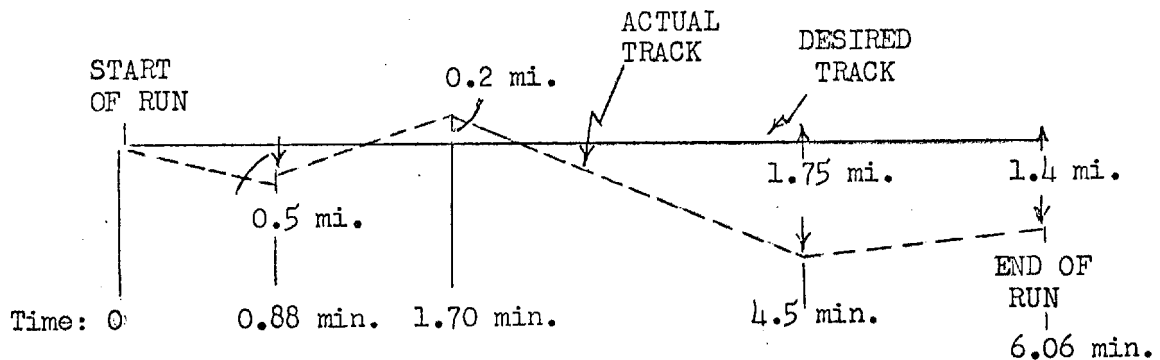
- c. Data Correlation: The data flash occurred every 4.87 seconds except for a brief period at the beginning of the run when it was 4.00 seconds. The instability is being corrected.
- d. Automatic Gain Control: During this flight automatic gain control was replaced by a variable fixed bias (0 volts and -0.4 volts).
- e. Antenna Beam Velocity: The output of the antenna acceleration network was inadvertently shorted to the Frequency Correction Command signal. No useful data was obtained from either of these signals.

FLIGHT CONDITIONS:

The autopilot performed satisfactorily in the light turbulence encountered during the flight. In the pilot's opinion the air turbulence was less than normally encountered at 40,000 feet.

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- a. Ground Speed: During the data run, momentary maximum and minimum ground speeds recorded were 845 and 818 knots. There was a gradual increase in the average ground speed from approximately 832 knots at the beginning of the data run to 838 knots at the end. Some oscillations of about 3 to 4 knots peak to peak occurred with random periods longer than six seconds. Higher frequency oscillations of one or two knots magnitude were observed by the pilot, but could not be seen on the recording. This is considered to be normal.
- b. Distance Off Track: The result of the distance off track recording is shown graphically in Figure 1. The figure is not to scale.



The track was allowed to deviate from the desired track, in the manner shown, so that the amount of course corrections would be minimum. The effect of being off the desired track is to change the area mapped slightly.

- c. Drift Angle: No drift angle signal was recorded because of a broken wire in instrumentation. From the pilot's notes, the largest drift angle encountered was 1° left.

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- d. Pitch: Pitch varied slowly from about $+3^\circ$ to $+1.8^\circ$ (nose up) during the data run. This variation, caused by changes in fuel loading, had been expected. Oscillations were present on this signal of $\pm .20^\circ$ magnitude and approximately .67 cps frequency.
- e. Roll: Roll drifted slowly during the data run from -1.5° (port wing down is negative) to $+1.4^\circ$. Superimposed on this drift were oscillations of $\pm 0.4^\circ$ with frequencies of 0.2 to 0.4 cps. Roll angles encountered were within system limitations except those existing during the course corrections shown in Figure 1. Deviations occurring at the time of correction exceeded the range of instrumentation. System film exposed during these periods (average 10 seconds) would not have contained any useful data.
- f. Heading Error: The heading error from the autopilot was small (less than 1°), and the average drifted from $+.3^\circ$ to 0° . Since there were no rapid heading changes and the turbulence was light, heading error varied as expected. There was a small ($\pm 0.1^\circ$) oscillation present which had a period of approximately 5 seconds. Because of the failure of drift angle instrumentation, it was not possible to correlate deflections in drift angle and heading error.
- g. Track Error: Track error, the angle between desired ground track and actual ground track varied between 4° right and 5.8° left. The large deviations occurred when the course corrections (see Figure 1) were made. Small oscillations, with periods of 2.5 to 5 seconds, occurred throughout the data run.

- h. Normal Accelerations of the Pod: During the ground run, before take-off, accelerations of 100-110 cps (amplitude $1/4$ g peak to peak) were recorded. This frequency increased to about 120-140 cps (amplitude doubled) during the flight. The traces were partially blurred on the oscillograph tape.
- i. Lateral Accelerations of the Pod: Flight data run frequencies of 110-150 cps were superimposed on a 15 cps oscillation (total amplitude ± 1.0 g). Ground oscillations were 100-110 cps with an amplitude of ± 0.5 g. The discussion of distortion on the normal acceleration also applies to this signal.
- j. Vibration: The output of the vibration sensor located in the antenna pod indicated that the vibrations present were similar to those previously recorded during the pod flutter flight. During flight at M 1.5, the frequency was 130 - 180 cps with amplitudes of $\pm .25$ g to $\pm .50$ g. The amplitude was reduced to about half and the frequency stayed the same during the ground run. During the ground run there was an additional oscillation at a frequency of 3 - 4 cps.
- k. Antenna Pod Error: The error signal indicated a constant error of $.10^\circ$ nose up as it had on the previous flight. This is apparently an error in the pod servo system. There was a ripple on the signal of $\pm .05^\circ$ at 8 - 10 cps.

3. Flight 85 (3/12/62) was flown over the area shown in Figure 2. All data from the radar observer, pilot or C.E.C. recording indicated that the system was operating normally during the flight. A close look at drift angle, ground speed, antenna beam velocity and frequency correction command was performed. However, the sensitivities of the latter two signals were too small to conclude whether the frequency correction command was correcting properly for fluctuations of each parameter. A table of all recorded signals is given below.

| <u>Signal</u> | <u>Range of Values</u> | <u>Pk to Pk Amp. of Osc.</u> | <u>Freq. of Osc.</u> | <u>Remarks</u> |
|--------------------------|-------------------------|------------------------------|----------------------|---|
| AGC | 0 V to (-)4V | - | - | Fixed Bias |
| Data Correlation | - | - | - | Data Pulse = 5.003 sec. |
| Power Supplies | - | - | - | Normal |
| Ground Speed | 840 to 849 | None | None | No definite oscillations - slowly drifting. Avg. speed = 844.0 Kn. |
| Ant. Beam Velocity | +5 ft/sec to - 5 ft/sec | None | None | Signal drifted slowly; Freq. Correction command followed closely. |
| Freq. Correction Command | 5.3 KC to 4.7 KC | - | - | Signal drifted slowly; Followed Ant. beam velocity more closely than drift angle or ground speed. |
| Drift Angle | 0.5°R to 2°R | 0.7° | 0.25 to 0.33 cps | Average value 1.5° Right. Correction Command Signal. |
| Distance Off Track | 0 to .75 n. mi. | None | None | No heading corrections made during this flight. |
| Track Error | 0.25°L to 1°R | 0.6° | 0.25 cps | Average value about 0.8°R; this signal follows drift angle very closely. |
| Heading Error | ± 0.2° | 0.2° | 4 cps | Autopilot operation was smooth; 4 cps oscillations occurred randomly. |

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| <u>Signal</u> | <u>Range of Values</u> | <u>Pk to Pk Amp. of Osc.</u> | <u>Freq. of Osc.</u> | <u>Remarks</u> |
|-----------------------|-------------------------|------------------------------|-------------------------------|---|
| Pod Error | + 0.1° Nose Up | 0.1° | 8 to 10 cps | Signal looked the same as previous flights, oscillations occurred when the plane pitched up. |
| Lateral Accel. of Pod | + .013 G to - .013 G | .025 G | 7.5 to 10 cps | Average value was 0 G. |
| Normal Accel. | - .3 G to 0 | .02 G | 8-9 cps | Osc. occurred when pod error signal oscillated; both occurred when plane pitched up. Second osc. of .78 cps (amplitude +.02 G) occurred, no correlation with other signals. |
| Vibration of Pod | (+) 2 G to (-) 2 G | 3 G | 35 to 45 cps & 125 to 140 cps | Two freq. present; 35 to 45 cps osc. had large amp. of 2 to 4 G pk. to pk.; 125 to 140 cps had amp of .8 G pk. to pk.; signal was like all other vibrations recorded. |
| Roll | -1.2° to +2.1° | .5° | Random | Signal was smooth, slowly drifting. |
| Pitch | +2.2° to +3.6° | .1° | 8 to 9 cps | Slow drifting signal with small 8 to 9 cps occurring randomly. Ripple on pod error and normal accel. follow the 8 to 9 cps osc. |

Temperatures Recorded During Flight 55

| <u>Item Sampled</u> | <u>Before Take-off</u> | <u>Start of Run</u> | <u>End of Run</u> | <u>After Landing</u> |
|-------------------------------------|------------------------|---------------------|-------------------|----------------------|
| Nose Compartment Air Temp. | 87° F | 51° F | 52° F | 59° F |
| Duplexer Driver Surface Temp. | 82° F | 64° F | 69° F | 97° F |
| Hi Voltage Power Supply Air Temp. | 120° F | 130° F | 135° F | 116° F |
| Pulse Forming Network Surface Temp. | 109° F | 109° F | 114° F | 129° F |

Antenna

Manifolds: For no. 2 antenna - complete

For no. 3 antenna - three of the eight required manifolds for antenna no. 3 have been received, electrically tested and accepted. Two other manifolds are ready to be shipped by GAR. Of the three remaining manifolds, two are electroformed and a mandrel for the third was shipped to GAR on March 13th.

Array Sticks: For no. 2 antenna - complete

For no. 3 antenna - a total of 74 array sticks out of a total of 128 required have been received. Of these 74 a total of 59 have been inspected, sealed and pressure tested, 4 are being sealed and 11 are being inspected. The remainder of 54 sticks are overdue from GAR.

Modules: For no. 2 antenna - all eight required modules have been "grown together", pressure tested and electrically tested. These modules are now being assembled to the antenna structure.

Power Dividers: For no. 2 antenna - all power divider parts for no. 2 antenna were formed by GAR and shipped to Technicraft. These parts were rejected by Technicraft, due to leaks during pressure test and were returned to GAR for rework.

Rework is supposed to be complete 3/14/62 and all parts shipped to Technicraft for assembly. Assembly should take about a week due to the cure cycle of the flexguide jacket.

For antenna no. 3 only a few of the power divider parts for no. 3 antenna have been made by GAR. Delay is blamed on the rework of power dividers for no. 2 antenna.

Phase shifters for all power dividers have been ordered and 4 pcs have been shipped to Technicraft to install in power dividers for no. 2 antenna. Remaining 6 phase shifters are due this date.

Switch Tubes

Effort on the X-16H1 has been directed toward improving isolation and operation at high duty (rep. rate of 3600 cps). A model is now being constructed which will be used to evaluate overall tube performance. If the device shows good performance, an attempt will be made to get some life information. This will be useful in selecting materials and processes for future tubes.

A WX-16H1 model constructed during the last period has been tested in the system with fair results. From reports received it worked well but had a tendency to occasionally arc over. This tube has been returned for further test to determine if the internal pressure has dropped.

Two WX-4554 ring dump switches have been built and are awaiting tests for optimizing phase shift. It is expected that work on this tube will be stepped up now that some of the problems associated with the X-16H1 have been solved.

About one man-week has been spent in modifying and testing EG and G tubes supplied by the Surveillance System Section.

Modulator

A pulse transformer and a PFN packaged in separate cans were received during this reporting period.

Temperature tests were run by mounting thermocouples on the above units and also the H.V. power supply, charging choke and modulator housing. After 85 minutes of operation with no external air blowing on the modulator, temperatures were found to be well within allowable limits except for the charging choke which indicated a case temperature of 130°C. External air was then applied to the modulator housing and operation of the test run was continued to two hours and ten minutes. Failure of the high voltage power supply at this time terminated the test run. Data resulting from this test indicated that:

- a. Application of external air to the modulator housing lowered temperatures of the PPM, pulse transformer and inside air approximately 15°C.
- b. All unit temperatures were satisfactory except for the charging choke which reached a final reading of 102°C.
- c. Copper temperatures of the charging choke and pulse transformer immediately following the power supply failure were found to be 151 and 120°C respectively.

Inasmuch as the max. hot spot temperature should not exceed 130°C for long life with paper and oil insulation, it is felt that the charging choke temperature indicated in (C) above would shorten the life to possibly 100-500 hours. No immediate failure should occur, however, and changes are now being made in the charging choke mounting to provide better air circulation.

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Several hours of modulator operation with another power supply resulted in a second power supply failure. Both of the failed units have been returned to the supplier for determination and correction of the cause.

It has been decided that the pulsewidth can be reduced from .6 to .4 microsecond and a PFN and charging choke have been ordered. These units are now ready for shipment to Westinghouse and will be interchangeable with the present units.

Modifications required to mount the separately packaged pulse transformer and PFN are now in process on the other two modulators.

Synchronizer

Synchronizer Generator

Some rework will be performed when parts are received to install a 13 mc output for use with the system test equipment.

Frequency Generator

New Bulova units have now been received and placed in each of the frequency generators.

Two of the generators have been unit tested and delivered to the systems (Flight Test and Environmental Test).

The third generator is in unit test and efforts are being directed towards improving the on-off ratio of the gated 120 mc output.

Stalo and Receiver

All three receivers have been incorporated in the systems and have been functioning properly.

Receivers #1 and #3 have the crossguide couplers with test arms.

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Recorder

General

Recorder #1 has been received by Westinghouse after updating.

The additional work required to complete a fourth recorder has been approved (lens optics recorder).

Recorder #3 has been assembled and work is continuing on Recorder #4.

Recorder #1

This recorder has been received by Westinghouse after completion of the retrofitting reported last month. Since then, the drive motor and pulley assembly was removed from Recorder #2 and assembled into Recorder #1 in order that film speed would be proper for the flight tests. Experience in the field indicated that instability in the L kc was due to feedback of the 8 and 16 kc pulse line. The addition of a diode to block this feedback cleared the difficulty. The high voltage power supply in Recorder #2, which was not properly regulated, was replaced with a power supply which operates correctly.

Recorder #3

A BX-4431 CRT was received this month and preliminary tests indicate a spot size of approximately .0008".

Also received was a fiber optics unfolding array from American Cytascope. The array specifications called for 10 micron fibers and measurements indicated that they were within specs.

Since this combination of CRT and fiber optics is the best that have been received to date, an extension on delivery date for the recorder was approved in order to run additional tests.

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Recorder #4

The work required to complete this recorder has been approved and all the additional assemblies required have been ordered.

Progress on this recorder is proceeding according to schedule.

The following releases for fabrication have been made this month.

1. Lens and M3 mirror mount assembly.
2. Trace viewing assembly.
3. Interconnecting cables.

The outside cover details were completed and scheduled for release next month. This is the last assembly to be released for fabrication.

The main assembly layout drawing was completed and all parts checked for releases.

Navigation Tie-In

All three units are complete and have satisfactorily passed unit tests.

Truss

Layout of the right truss is complete and detail drawings have been started.

The mock-up will be started during the next reporting period.

Stress analysis of the truss is 75% complete.

System Stress Analysis

The installation load report is complete and will be available during the next reporting period.

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Composite Test

System #3 was delivered on March 1, 1962 (less the modulator, antenna and minor exceptions).

Test Equipment

Design Evaluation Equipment

All units with exception of the Azimuth Resolution Test Pattern Generator have been mounted in the rack. The film evaluators are not completed as yet.

The problems and areas of progress will be detailed in the following paragraphs.

Transponder

The transponder is mounted in the rack and is ready for integration with the rest of the test system.

Clutter Generator

The Clutter Generator is mounted in the rack and is ready for integration with the rest of the system. The antenna pattern filter referred to in the last progress is not available and is not installed in the unit.

A bandpass filter which simulates the main lobe of the antenna and approximates the envelope of the sidelobes has been designed and installed. This filter will not be considered an interim fix as was indicated in the previous report but will be a permanent design in the unit.

Range Resolution Test Pattern Generator

The Range Resolution Test Pattern Generator is mounted in the rack and is ready for integration with the rest of the test system.

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Azimuth Resolution Test Pattern Generator

The redesigned gear train assembly has been received from the Model Shop and has been incorporated into the servo system. The antenna pattern filter from an outside source was received on Friday, 16th. The characteristic data supplied with the filter indicates that it will be acceptable. It will be incorporated and tested with the unit.

The jitter free delay circuit has been completed and tested as a unit. It is ready to be mounted in the rack and integrated with the rest of the system.

Azimuth Resolution Optics Assembly

Some of the sub-assemblies have been received from the Model Shop. The main housing of the receiver portion of this assembly was received in the week ending March 11th. The main housing of the projector assembly has not been received from the Model Shop as yet.

Assembly of this unit is approximately 15% complete.

Range Resolution and Dynamic Range Optics Assembly

Assembly of this unit was completed during the week ending March 18th. Some minor errors have been found and corrected. To date the output has been displayed on a scope only. It will be tested with the film evaluator electronics during the week ending April 1st.

Film Evaluator Electronic Circuitry

The film evaluator electronic circuitry has been completed and tested as a unit. It will be tested with the optics assembly during the week ending April 1st.

Mechanical Design and Packaging

All of the power supplies have been mounted in the rack along with the Transponder, Clutter Generator, Range Resolution Test Pattern Generator, Power Relay Chassis, Control Panel and Blowers. The wiring necessary to interconnect these units has been installed in the wiring harness. The power supplies, the cooling system, the Power Relay Chassis and the Control Panel have been tested and function properly.

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SECRET During the week ending March 25th, the remainder of the wiring harness will be installed.

The most economical approach to the design of the table which will support the film evaluators appears to be the modification of a metal work bench. The bench has been ordered from a local supplier.

A framework to support the evaluator electronics, a framework to stiffen the legs and casters will be installed. The design and fabrication of the table in this manner will be approximately 50% of the cost that would be involved if the table were completely fabricated at Air Arm.

Doppler Frequency Tracker

Mechanical design of the DFT has begun, including allotment of space to the various circuits and design for fabrication of the various chassis. The unit will consist of four basic chassis. Nominally, they are the IF, LO, Signal and DC Amplifier, and Filter Chassis.

The front end has been paper-designed. A layout is being prepared. In this category are the amplifiers, filters, and mixers in both the IF and LO sections, plus the gater and synchronous demodulator.

The toroid coils and component ovens were received. A filter circuit was breadboarded per the paper design, and minor modifications made. Preliminary tests were satisfactory. Packaging of components in the oven is being studied, and circuit design is being improved. These filters will serve as the spectral line and frequency discriminator filters.

The booster amplifier, range gate generator, and signal-presence amplifier have all been checked out. They are being laid out on circuit boards. A ready-made DC amplifier has been acquired and will be incorporated into this chassis.